A Cold Neutron Beamline at the SNS for Nuclear, Particle, and Astrophysics

Michael Snow, Indiana University

This appendix is a brief status report on the cold neutron beamline proposed for the SNS for nuclear, particle, and astrophysics, which is a part of one of the recommendations from the Oakland Town Meeting. Over the last decade this field of physics has attracted an energetic community of academic and national lab researchers and includes a number of talented younger scientists. A special symposium at the October 1999 DNP meeting discussed 9 different projects at NIST and LANSCE, involving 97 participants from 23 different institutions. It is envisioned that these scientists would form the core group of users for this beamline.

Possible experiments that could be performed with a pulsed neutron beamline at the SNS were discussed at the International Workshop on Fundamental Physics with Pulsed Neutron Beams, held at Research Triangle Park, NC, in June 2000. The following 4 classes of experiments were identified which would be able to exploit the pulsed nature of the neutron source:

(1) experiments to measure the weak NN interaction [Included here are measurements of the parity-violating gamma asymmetry in np and possibly nD capture and parity violating neutron spin rotation measurements in np and possibly nD and n-4He. These experiments would provide essential information on the weak NN interaction complementary to that obtained from measurements with protons.];

(2) in-beam neutron decay experiments which require absolute neutron polarization measurements (A and B coefficients) [Precision measurements of these correlations would determine the CKM matrix element V_{ud} to high accuracy and allow a test of the unitarity of the CKM matrix. V_{ud} as determined from superallowed transitions in nuclear beta decay leads to over a 2σ deviation of the CKM matrix from unitarity.];

(3) measurements with ultra-cold neutrons (such as neutron lifetime measurements and the neutron EDM) which can be conducted within a superfluid ^{4}He moderator [Neutron lifetime measurements are needed for V_{ud} and also as input to Big Bang nucleosynthesis, where it influences ^{4}He production. A nonzero EDM at a level 2 orders of magnitude below the current limit would represent a new source of T violation and would also be the right size to be relevant to the cosmological baryon asymmetry.];

(4) neutron cross section measurements in the keV range on radioactive samples for nuclear astrophysics [A number of neutron-induced cross sections on radioactive nuclei are important for stellar nucleosynthesis but have never been measured in the lab. The SNS would make possible measurements on several relevant radioactive nuclei.].

The physics interest in improved measurements of the weak NN interaction, neutron beta decay, and the neutron EDM are described in the Oakland Town Meeting White Paper. The proceedings of the Triangle Park conference, to be published by World Scientific, describes the physics justification and the experiments in more detail. Some

general observations were also made at this meeting regarding which moderators would be best for certain experiments. Experiments in class (4) require a fast epithermal neutron spectrum. Experiments in classes (1), (2), and (3) are best done with a cold neutron spectrum and the highest flux (precise neutron time-of-flight resolution is not required).

A Letter of Intent to the SNS for this beamline was submitted in fall 2000 and was discussed in a presentation to the SNS Scientific Advisory Committee in Jan. 2001. The recommendation from this committee will appear soon. If approved, the next step is the submission of a formal proposal to construct the beamline. This beam would be the most intense source of cold neutrons, pulsed or CW, in the US. With the SNS operating at 2MW, the flux will be larger than the LANSCE neutron beam, now under construction, by a factor of 7 and larger than the NIST cold neutron beam by a factor of 4, according to current calculations of moderator performance.

The design of the beamline is in progress. It would consist of 15-20 meters of 10 cm X 10 cm cross section super-mirror guide with radiation shielding, choppers at various locations to shape the neutron pulse and suppress backgrounds, and a shielded cave for the experiments. A straight guide would be required to accommodate the cross section measurement program for nuclear astrophysics. The current estimate for these items is $1.5M. Costs for construction and installation must be added to this figure but cannot be estimated yet without more detailed input from the SNS project scientists.